## TECHNICAL WORK MAY NOT BEGIN PRIOR TO CO APPROVAL

NASA/GODDARD SPACE FLIGHT CENTER

# REQUEST FOR TASK PLAN / TASK ORDER

| CONTRACTOR | CONTRACT NO./TASK NO. | | | JOB ORDER NUMBER | APPROP. FY |
|---|---|---|---|---|---|
| | NAS5- | TASK NO. | AMENDMENT | | |
| QSS Group, Inc. | 99124 | 313 | | 582-258-90-81-89 | FY00 |

**TASK TITLE:** (NTE 80 characters; include Project name)

On-board Satellite Cloud Contamination Detection with Atmospheric Correction

**APPROVALS:** (Type or print name and sign)

| | DATE | ORG CODE | MAIL CODE | PHONE |
|---|---|---|---|---|
| ASSISTANT TECHNICAL REPRESENTATIVE (OR TASK MONITOR) Jerry Miller | 6/26/00 | 582 | 582 | (301)286-5823 |
| BRANCH HEAD Elaine Shell | 6/26/00 | 582 | | (301)286-7104 |
| CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE (COTR) Robert S. Lebair, Jr. | 6/29/00 | 560 | | 301-286-6588 |

| FLIGHT HARDWARE, CRITICAL GSE OR SOFTWARE? *(IF YES, NEED CODE 303 CONCURRENCE NEXT BLOCK)* (x) NO ( ) YES | CONTRACTING OFFICER'S QUALITY REP. Larry Moore | DESIGNATED FAM: |
|---|---|---|

| The contractor shall identify and explain the reason for any deviations, exceptions, or conditional assumptions taken with respect to this Task Order or to any of the technical requirements of the Task Order Statement of Work and related specifications. The contractor shall complete and submit the required Reps and Certs. | (To be completed by Contracting Officer) C.O. Requested Quote on: Date: |
|---|---|

Contractor will develop specification or statement of work under this task for a future proc (x) NO ( ) YES

Flight hardware will be shipped to GSFC for testing prior to final de ( x) NO ( ) YES ( ) N/A

Government Furnished Property/Faciliti (x) NO ( ) YES -- SEE LIST OF GFP (offsite only) / FACILITIES (onsite only)

Onsite Performance: (x) NO ( ) YES If yes: ( ) TOTAL ( ) PARTIAL

If partial, indicate onsite work in SOW by asterisk (*)

Surveillance Plan Attached: (x) NO ( ) YES

Highlighted Contract Clauses: *(to be completed by Contracting Officer)*

The effective date of this task order can be found at the Contracting Officer's signature box below.

### INCENTIVE FEE STRUCTURE (check one)

(See Contract NAS5-99124, Attachment K, Incentive Fee Plan)

| | _x_ No. 1 | ___ No. 2 | ___ No. 3 | ___ No. 4 | ___ No. 5 |
|---|---|---|---|---|---|
| Cost | 10% | 50% | 25% | 25% | % |
| Schedule | 15% | 25% | 25% | 50% | % |
| Technical | 75% | 25% | 50% | 25% | % |

*(To be completed by Contracting Officer,*

The target cost of this task order is $ 132,491 .

The target fee of this task order is $ 8,612 .

The total target cost and target fee of this task order as contemplated by the Incentive Fee clause of this contract is $ 141,103 .

The maximum fee is $ 12,587 .

The minimum fee is $0.

**AUTHORIZED SIGNATURE:**

THIS TASK ASSIGNMENT IS ISSUED ACCORDING TO THE CONTRACT CLAUSE "TASK ASSIGNMENTS AND REPORTS"

| SIGNATURE OF CONTRACTING OFFICER | DATE 9/1/00 | ELIZABETH J. AUSTIN CONTRACTING OFFICER TYPED NAME OF CONTRACTING OFFICER |
|---|---|---|

**CONTRACTOR'S ACCEPTANCE:**

| AUTHORIZED SIGNATURE | DATE |
|---|---|

GSFC FORM 703-1845       12/98 (OLDER VERSIONS ARE OBSOLETE)

DISTRIBUTION: CONTRACTOR, CONTRACTING OFFICER, COTR, CODE 303, RESOURCES ANALYST, ASSISTANT TECHNICAL REPRESENTATIVE

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| QSS Group, Inc. | 99124 | **313** | |

Applicable paragraphs from contract Statement of Work:

**STATEMENT OF WORK:**    (Continue on blank paper if additional space is required)

This 1 year Task results from the selection of a proposal entitled "On-Board Cloud Contamination Dectection with Atmospheric Correction", AIST-0037-0074, in response to NASA Research Announcement (NRA) for the Advanced Information Systems Technology (AIST) Program, NRA-99-OES-08. Mr. Patrick H. Stakem of QSS Group-MEDS is co-investigator on this proposal.

**PERFORMANCE SPECIFICATIONS:**

Management: Accomplishment of objectives, clear incremental progress as shown in monthly reports and bi-weekly meetings, efficient and appropriate staffing, responsiveness to issues posed by task monitor, coordination and good working relationship with task monitor and other related contractor efforts, flexibility within scope of the contract, and schedule adhererence

Technical Objectives: Applicability of recommendations, relevance of findings to other projects, readability and comprehensiveness of reports.

Deliverables: Technical accuracy, appropriateness to NASA community use, well-written report, use of illustrative graphics to ırify points.

When providing technical reports to the Task Monitor, the contractor shall make detailed explanations of reported progress in terms of: (1) models, assumptions and approaches; (2) selected algorithms or deviations; (3) lines of code completed; (4) intermediate test results, where applicable; and (5) problems and schedule impacts on deliverables.

**APPLICABLE DOCUMENTS:**

NRA-99-OES-08
On-board Satellite Cloud Contamination Detection with Atmospheric Correction, AIST-0037-0074

**TASK END DATE:**        ~~8/15/01~~ 9/4/01

**MILESTONES/DELIVERABLES AND DATES:**
- Creation of LUTS for each of first 2 AVHRR channels and 1 LUT for solar spectral irradiance: 1/1/01
- Determination of Aerosol Optical Depth per pixel directly from imagery: 3/1/01
- Determination of day, night, sea, land or coast: 3/1/01
- DN correction for aerosol, water vapor and atmospheric gases: 5/1/01
- Conventional atmospheric correction technique: 7/1/01
- Performance test of "dark object technique" with comparison to conventional method: 8/15/01
- Bi-weekly meetings with task monitor
- Inputs to reports required by the NRA for AIST Management Office: (Detailed descriptions of reports attached.)
- Technical Progress Report: Monthly, due the 15th of the month reporting the previous month's activities

**PERFORMANCE STANDARDS:**
      Schedule: On-time delivery/completion of the deliverables/milestones
      Technical: ATR's acceptance of the deliverables

**FINAL DELIVERY DESTINATION (NAME, BLDG. ROOM):**
Jerry Miller, building 23, room W227

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## STATEMENT OF WORK

Under this proposal, using NOAA AVHRR Level 1b data (HRPT format), the contractor shall implement the "dark object" approach to atmospheric correction in an automated mode for Channels 1 and 2 in a simulated on-board spacecraft computing environment including corrections for water vapor and gaseous absorption. The contractor shall code algorithms in 'C' Programming Language in a style that resembles the register transfer level (RTL) model, which is a dataflow level of abstraction. This is necessary because all 'C' coded algorithms must be converted to VHDL in order to run on FPGAs. A/RT Builder software from Frontier Design Inc. requires RTL style 'C' in order to automatically make the conversion.

The contractor shall support the implementation of an on-board threshold method of cloud detection in a very limited scope. Cloud screening threshold tests vary depending on whether, at the time of satellite overpass, it is night or day or the underlying surface type is sea, land or coast. The contractor shall develop a method, suitable for automatic on-board implementation, for determining these variables (day, night, sea, land, coast). One possible method would make use of on-board ephemeris data, a surface map and the spacecraft clock.

Ideally, VHDL coding of all algorithms intended for on-board implementation will be taking place in parallel with 'C' coding; therefore, the contractor shall work closely with those personnel involved in such efforts, periodically providing them with whatever algorithmic descriptions in whatever form are available.

Consult the following references for a data description and RTL style coding:

Katherine B. Kidwell (editor), "NOAA Polar Orbiter Data User's Guide", November, 1998 REV.

Frontier Design Inc., "A|RT Builder User's and Reference Documentation", Version 2.1, March 20, 2000.

To implement the "dark object" technique on a pixel-by-pixel basis, the contractor shall:

(1) Create a Look-up Table (LUT) for each of the first 2 AVHRR bands of wavelengths 0.639 and 0.845 micrometers. Each table shall contain values of path radiance, downward flux, transmittance and atmospheric albedo for 9 solar zenith angles (10, 20, 30, 40, 50, 60, 66, 72 and 78 degrees), 13 observation zenith angles (0 to 78 degrees in 6-degree increments), 19 observation azimuth angles (0 to 180 degrees in roughly 10-degree increments), and 4 aerosol optical thicknesses (0.0, 0.25, 0.50 and 1.0). Observation height need only be commensurate with NOAA spacecraft. Create one additional LUT of solar spectral irradiance for the wavelengths in question.

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(2) Determine the aerosol optical thickness for each image pixel and then interpolate between LUT entries to derive path radiance, downward flux, transmittance, and atmospheric albedo.

(3) Use the inverse of the 1-dimensional radiative transfer equation to solve for surface reflectance and convert this to surface radiance and a digital number (DN), i.e. the brightness value which ranges from 0 to 1023 counts by inverting the calibration equation.

The following references may be consulted for detailed explanations of the "dark object approach" to atmospheric correction and one possible method of deriving aerosol optical thickness directly from earth imagery using empirical formulas between optical thickness and path radiance:

Yoram J. Kaufman, Hassan Fallah-Adl, Joseph JaJA, Shunlin Liang, John Townshend, "Fast Algorithms for Removing Atmospheric Effects from Satellite Images", IEEE Computational Science and Engineering, Volume 3, Issue 2, 1996, pp. 66-77.

R.S. Fraser, R.A. Ferrare, Y.J. Kaufman, B.L.Markham, S. MAttoo, "Algorithm for Atmospheric Corrections of Aircraft and Satellite Imagery", International Journal of Remote Sensing, Volume 13, No. 3, February 1992, pp. 541-557.

Hassan Fallah-Adl, Joseph JaJa, Shunlin Liang, "Efficient Algorithms for Estimating Atmospheric Parameters for Surface Reflectance Retrieval", Proceedings of the 1996 International Conference on Parallel Processing, 1996, Volume 3, pp. 132 -141.

Yoram J. Kaufman, Claudia Sendra, "Algorithm for Automatic Atmospheric Corrections to Visible and Near-IR Satellite Imagery", International Journal of Remote Sensing,, Volume 9, No. 8, August 1998, pp. 1357 - 1381.

Shunlin Liang, Hassan Fallah-Adl, Satya Kalluri, Joseph JaJa, Yoram J. Kaufman, John R.G. Townshend, "An Operational Correction for Landsat Thematic Mapper Imagery Over the Land", Journal of Geophysical Research, Volume 102, No. D14, July 27, 1997, pp. 17173 -17186.

Hassan Fallah-Adl, Joseph JaJa, Shunlin Liang, Yoram J. Kaufman, John Townshend, "Efficient Algorithms for Atmospheric Correction of Remotely Sensed Data", available online at URL http://www.umiacs.umd.edu/labs/GC/atmo and (possibly) appearing in Proceedings Supercomputer '95, IEEE Computer Society Press, December 1995.

Yoram J. Kaufman, Didier Tanre, "Strategy for Direct and Indirect Methods for Correcting the Aerosol Effect on Remote Sensing: From AVHRR to EOS-MODIS", Remote Sensing of Environment, Volume 55, Number1, January 1996., pp. 65-79.

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Yoram J. Kaufman, "Aerosol Optical Thickness and Atmospheric Path Radiance", Journal of
Geophysical Research, Volume 98, No. D2, February 20, 1993, pp.2677 - 2692.

As a method of verifying the accuracy of the "dark object" approach to atmospheric correction,
the contractor shall use a conventional atmospheric correction technique on the same earth scene
for comparison. Since it would be of interest to compare execution speed as well, this algorithm
shall also be coded in 'C' but RTL style is unnecessary. One description of this technique, was
authored by Forster (see full reference below) for LANDSAT MSS. It could be adapted for
NOAA AVHRR. It requires that the temperature, relative humidity, pressure and visibility and
average height above sea level be known for the time of satellite overpass.

Consult the following reference for Forster's method:

B.C. Forster, "Derivation of Atmospheric Correction Procedures for LANDSAT MSS with
Particular Reference to Urban Data", International Journal of Remote Sensing, Volume 5,
Number 5, Sepember-October 1984, pp. 799-817.